Helping States Slow Sediment Movement

A High-Tech Approach to Clean Water Act Sediment Requirements

When ARS's National Sediment Laboratory scientists were asked by Mississippi officials to study James Creek, in the northeastern part of the state, they saw more than a chance to conduct a local field project.

They envisioned adding to a developing methodology—one aimed at helping states comply with Clean Water Act sediment requirements—by joining computer-modeling capabilities with river-related geologic studies.

During a 90-day analysis of the sediment-impaired creek, the scientists integrated for the first time large-scale geomorphology—the study of forms on Earth's surface and subsurface and the processes that create them—with two prominent ARS watershed and channel models to monitor sediment movement in water bodies.

The researchers work for the Oxford, Mississippi-based laboratory's Channel Watershed and Processes Research Unit (CWPRU).

Hydraulic engineer Carlos Alonso, the unit's research leader, says the union of these tools can enable state officials nationwide to meet sediment pollution-control criteria for many watersheds by helping them determine actual sediment loads and establish reference loads—all the while sustaining a competitive agricultural economy.

"These detailed computer models help us determine how soil erosion and sediment loading change over time," says Alonso. "In James Creek, we laid a foundation and set standards for how this kind of research might be done elsewhere."

The unit is already applying the integrated method to projects in Alabama, California, Kansas, Michigan, and elsewhere in Mississippi.

This focus on sediment pollution criteria is fueled by a renewed effort among states to comply with the Clean Water Act. The act calls for states to identify pollution-impaired water bodies and develop plans for meeting requirements for Total Maximum Daily Loads (TMDLs).

TMDLs specify the maximum amount of a pollutant a water body can receive and still meet quality standards set for its designated use by states, territories, and tribes. Compliance is monitored by each state in concurrence with the United States Environmental Protection Agency. Having a way to compare actual and reference loads assists greatly in creating sediment TMDLs for specific watersheds.

Sediment as a Pollutant

Of all pollutants requiring TMDLs, none is as prevalent—or as potentially damaging—as sediment, says Alonso. "Physical, chemical, and biological damage associated with sediment flow costs about $16 billion annually in North America," he says. "Excessive erosion and the transport and deposition of sediment in surface waters are major water-quality problems."

STEPHEN AUSMUS (K10750-1)

Hydrologist Mark Griffith (left), hydraulic engineer Carlos Alonso (center), and technician Brian Bell analyze high-altitude aerial photographs of the James Creek area.

RON BINGNER (K10754-1)

An aerial view of a section of James Creek, in Mississippi, where channel incision has led to rapid bank erosion causing land loss and high suspended sediment loads within the water.

While establishment of TMDLs was first prescribed in the Clean Water Act of 1972, few have actually been developed, says unit geologist Andrew Simon. But citizen concern and court challenges have propelled recent action. The Mississippi Department of Environmental Quality responded by requesting the James Creek study so that the state could develop its federally mandated water-quality targets for sediment.

Alonso says one reason for delays in setting sediment TMDLs is that no proven methods existed for defining how much sediment constitutes a pollution hazard. "Procedures had to be developed for identifying streams that are especially vulnerable to erosion and sedimentation and for relating the sediment TMDLs to the designated uses of waterways in different regions," he says.

Agricultural engineer Ronald Bingner says this task is complex, given the varied geography and management of land within watersheds. Eighty-four "ecoregions" have been identified in the continental United States based on similarities in climate, geology, topography, and ecology. "We hope our work at James Creek will make it easier to set target values in other ecoregions," he says.

In a two-pronged approach, the research team combined extensive field measurements and their geomorphic analysis with simulations generated by two computer models: the Annualized Agricultural Non-Point Source Pollutant watershed model and the Conservational Channel Evolution and Pollutant Transport System model.

The first model helps evaluate pollutant loadings within a watershed and the effect farming and other activities have on pollution control. It does this by continuously simulating runoff of sediment and chemical pollutants. It was developed through a partnership between ARS and USDA's Natural Resources Conservation Service.

The second model predicts how channel evolution and pollutant loadings will be affected by bank erosion and failures, streambed buildup and degradation, and streamside riparian vegetation. It was developed by Eddy Langendoen, a University of Mississippi scientist who collaborates with CWPRU on modeling channel processes.

Technology Complements Field Methods

Besides advancing computer-modeling capabilities, the James Creek research also builds on significant, earlier sediment-related field methods.

For example, Simon and his colleagues used his expertise in geomorphology to create new ways to identify reference sediment loadings for watersheds.

"It was during studies of watersheds in the Cascade Mountains and along the Loess Bluff Line here in Mississippi that we first developed the descriptive techniques used in James Creek," Simon says. "These techniques, which include aerial reconnaissance, channel surveys, and sampling and testing of stream boundary sediments, worked for those very diverse regions, and we're expanding their use nationwide."

Simon says CWPRU is conducting reference research for 3,000 sites throughout the United States.

STEPHEN AUSMUS (K10752-1)

Hydrologist Mark Griffith (top) uses a bore hole shear device to determine the cohesion of bank materials while technician Brian Bell prepares for a submerged-jet test on fine-grained lower bank materials. The data from these tests will be used to determine erodibility.

A Perfect Test Case

James Creek, which flows for 19.5 miles past uplands and fields and through channels, was an ideal waterway on which to reinforce earlier lessons. Its watershed is highly agricultural, mostly made up of cultivated croplands, pastures, or fallow land. Like many Mississippi streams, it is extensively channelized. Only the lower 4.1 miles retain a natural sinuous alignment.

As such, it illustrates a "Stages of Channel Evolution" theory Simon and a colleague developed in 1986, when he worked for the U.S. Geological Survey. The theory describes a stream's erosive evolution in six stages, starting with a stable, undisturbed channel (stage I) and ending with a refilled channel (stage VI). In between, the stream is disturbed by some large-scale event, eroded, and then restabilized. (See box.)

Through the two computer models described earlier and similar field and modeling research studies, CWPRU scientists have concluded that stages I and VI present the best conditions under which to determine reference standards for sediment loadings. Another interesting finding was that streambanks—not uplands and fields, as many believe—are the main contributors to sediment pollution in many disturbed stream systems.

"Perhaps future decisions about reducing sediment loadings will need to be based more on stream-channel processes and on stabilizing eroding reaches and tributaries," says Alonso.

Each of the unit's scientists has been involved in this research. Bingner and Alonso head the modeling aspects, while Simon and hydraulic engineer Roger Kuhnle specialize in sediment yield and channel loadings. Former ARS geologist Sean Bennett led studies on sediment loading effects on reservoirs, lakes, and flood-control structures.

Simon says current and upcoming projects include in-depth studies of each ecoregion. "We also want to identify at least two damaged and two reference sites in each ecoregion for detailed analysis of sediment transport," he says.

"Watershed-wide problems require an integrated approach to developing sediment pollution standards that address all concerns," says Alonso. "Combining field measurements, geomorphic analyses, and numerical models has proven to be a powerful way for evaluating reference and actual sediment-transport conditions. The James Creek research shows how these techniques can be applied nationwide."—By **Luis Pons,** ARS.

This research is part of Water Quality and Management, an ARS National Program (#201) described on the World Wide Web at www.nps.ars.usda.gov.

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The six stages of Simon's Channel Evolution Model are as follows:

Stage I: The waterway is a stable, undisturbed natural channel.

Stage II: The channel is disturbed by some drastic change such as forest clearing, urbanization, dam construction, or channel dredging.

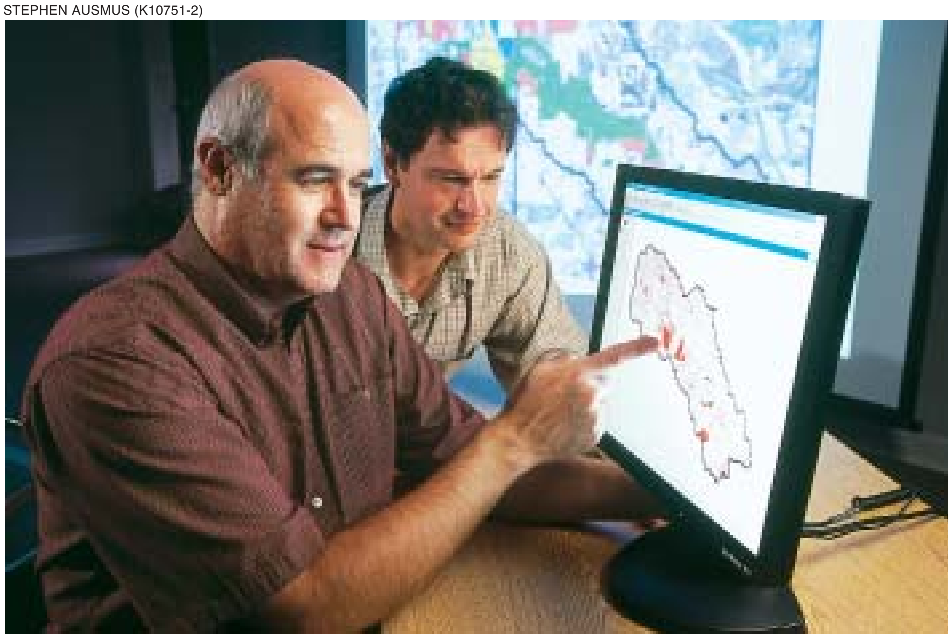
Stage III: Instability sets in with scouring of the bed.

Stage IV: Destructive bank erosion and channel widening occur by collapse of bank sections.

Stage V: The banks continue to cave into the stream, widening the channel. The stream also begins to aggrade, or fill in, with sediment from eroding channel sections upstream.

Stage VI: Aggradation continues to fill the channel, re-equilibrium occurs, and bank erosion ceases. Riparian vegetation once again becomes established.

STEPHEN AUSMUS (K10751-2)



Watershed and channel computer simulation models help scientists identify sediment-producing sources. Here, agricultural engineer Ron Bingner (left) and hydraulic engineer Eddy Langendoen study data generated by a model.